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(54) **METHOD AND APPARATUS FOR MAKING PLASTIC FILM, AND PLASTIC FILM**

VERFAHREN UND GERÄT ZUR HERSTELLUNG EINER KUNSTSTOFFFOLIE, UND KUNSTSTOFFFOLIE

PROCEDE ET APPAREIL DE FABRICATION D'UN FILM PLASTIQUE, ET FILM PLASTIQUE

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Description

[0001] The invention relates to a method for making a plastic film, the method comprising extruding a plastic film and orientating it.

[0002] The invention also relates to an apparatus for making a plastic film, the apparatus comprising an extruder and at least one orientation device for orientating the extruded film.

[0003] The invention further relates to a plastic film which comprises bubbles with the maximum diameter of about 100 micrometers and the maximum height of about 10 micrometers.

[0004] Making a plastic film by extruding it and then orientating it is known e.g. from US patents 3,244,781 and 3,891,374. It is, however, difficult to make thin and in particular thin foamed films using these solutions.

[0005] EP publication 0,182,764 discloses a thin polypropylene film which contains wide and flat disk-like bubbles, which are about 80 micrometers in length and about 50 micrometers in width. The film is produced by extruding material which has been foamed chemically or by means of gas and by orientating the extruded material biaxially. The result is a very versatile plastic film. However, the foaming degree of the film is less than 50%, which is why the properties of the film are not good enough for all purposes.

[0006] Furthermore, it is not possible to produce thin films of polymethylpentene or cyclic olefin copolymer using the prior art solutions.

[0007] The object of this invention is to provide a very good and thin foamed plastic film and a simple and reliable method and apparatus for making said plastic film.

[0008] The method of the invention is characterized in that before extrusion material is mixed into the plastic of the plastic film, cavitation bubbles are formed in the plastic film to be stretched due to the influence of the material, after extrusion the plastic film is orientated by stretching, and simultaneously with orientation pressurized gas is arranged to act on the plastic film so that the gas diffuses in the cavitation bubbles, and thus bubbles containing gas are formed in the plastic film.

[0009] The apparatus of the invention is characterized in that the apparatus comprises gas supply means arranged in one orientation device for feeding pressurized gas into the plastic film simultaneously with orientation by stretching so that the fed gas diffuses in the cavitation bubbles that are formed in the plastic film during stretching, and thus bubbles containing gas are formed in the plastic film.

[0010] The plastic film of the invention is characterized in that material is mixed into the plastic of the plastic film, cavitation bubbles are formed in the plastic film to be stretched due to the influence of the material, and the plastic film is subjected to stretching and to pressure of pressurized gas simultaneously with stretching so that the bubbles contain said gas, the foaming degree of the plastic film being over 70%.

[0011] The basic idea of the invention is that a film is extruded from plastic material by means of an extruder and material has been mixed into the plastic so that when the plastic is stretched, cavitation bubbles are formed in the material particles mixed into the plastic. The film is orientated by stretching and at the same time gas is fed into the film under high pressure so that the gas diffuses in the cavitation bubbles and causes overpressure in them. The idea of a preferred embodiment is that after the first orientation the plastic film is orientated by stretching it in the direction substantially perpendicular to the first orientation direction, and thus the overpressure is released in the cavitation bubbles and the bubbles expand.

[0012] An advantage of the invention is that very thin films with a foaming degree of about 70 to 90% can be provided in a relatively simple manner. An advantage of the high foaming degree is that the electric and mechanical properties of the film are very good. A further advantage is that the method and apparatus can be used for making a film for example of polymethylpentene or cyclic olefin copolymer.

[0013] The invention will be described in greater detail in the following drawings, in which

Figure 1 is a schematic cross-sectional side view of an apparatus of the invention,
Figure 2 is a partially cross-sectional top view of the apparatus illustrated in Figure 1,
Figure 3 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line A-A,
Figure 4 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line B-B,
Figure 5 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line C-C,
Figure 6 is a schematic cross-sectional top view of an extruder used in the apparatus of the invention,
Figure 7a is a cross-sectional side view of a plastic film extruded by the apparatus of the invention before orientation of the film,
Figure 7b is a cross-sectional side view of the plastic film extruded by the apparatus of the invention after longitudinal orientation,
Figure 7c is a schematic top view of the plastic film illustrated in Figure 7b, and
Figure 7d is a schematic top view of the plastic film made by the apparatus of the invention after longitudinal and cross-direction orientations.

[0014] Figure 1 is a side view of an apparatus according to the invention. The apparatus comprises an extruder 1. The extruder may be for example conical, i.e. it comprises a cone-shaped rotor 2, outside of which there is an outer stator 3 whose surface at least on the rotor 2 side is cone-shaped, and inside the rotor there is an inner stator 4 whose surface at least on the rotor 2 side is cone-shaped. When the rotor 2 rotates, it extrudes material which is between the rotor 2 and the sta-

tors 3 and 4 from the extruder 1 in a manner known per se. For the sake of clarity the figures do not illustrate e. g. the rotating means of the rotor or the feeding devices for feeding the material to be extruded into the extruder 1. The extruder 1 may comprise more than one rotor 2 and more than two stators 3 and 4. In that case the extruder 1 can be used for extruding multilayer products. The solution with one rotor 2 and two stators 3 and 4 can be used for making two-layer products. The end portion of the inner stator 4 is wide and tapers in the vertical direction so that together with the nozzle 6 it forms a relatively flat and wide gap through which the plastic 5a is extruded. After the nozzle 6 there is a calibration piece 7 whose nuts are used for adjusting the height of the gap, which allows to define the thickness of the plastic film 5 to be obtained from the extruder 1.

[0015] After the extruder 1 the plastic film 5 is cooled by a cooling device 8. The cooling device 8 may comprise e.g. a cooling roll 9, which is arranged in a cooling tank 10 containing a cooling medium, e.g. water. The plastic film 5 is arranged to be pressed against the cooling roll 9. The apparatus according to Figure 1 uses auxiliary rolls 11 for guiding the plastic film 5 at several points.

[0016] After cooling the plastic film 5 is guided to a machine direction orientation device 12. The machine direction orientation device 12 comprises orientation rolls 13 whose velocities are adjusted so that they can be used for stretching the plastic film 5 and thus for orientation in the machine direction. If desired, the velocity of each orientation roll 13 can be adjusted separately. The machine direction orientation device 12 may also comprise heating means 14, such as radiation heaters, for heating the plastic film 5 in a manner known per se. The orientation rolls 13 can also be used for heating the plastic film by supplying a heating medium, such as heated oil, to the orientation rolls 13 so that the orientation rolls 13 become warm. If desired, the temperature of each orientation roll 13 can be adjusted separately.

[0017] The orientation rolls are arranged in a discharge chamber 15. Pressurized gas, preferably air, is fed into the discharge chamber 15 along a gas supply pipe 16. Instead of air, nitrogen or another gas or gas mixture, for instance, may be used as the gas to be fed. The gas to be fed may also be selected according to the desired electric properties. For example, in respect of the dielectric strength of the product it would be advisable to use sulphurhexafluoride SF_6 and in respect of chargeability e.g. argon. The pressure of the gas to be fed is relatively small compared to the typical foaming methods, being preferably about 10 bars, but it may vary between 3 and 20 bars, for instance. Suitable material, such as calcium carbonate particles, is mixed into the plastic 5a of the plastic film 5, and due to the influence of the particles the joint surfaces of the plastic molecules and the mixed material are torn during orientation, and thus cavitation bubbles are formed. When orientation is performed by arranging pressurized gas to act on the plastic film 5, the gas in question diffuses in the cavitation bubbles and causes overpressure in the bubbles. In the discharge chamber 15 the pressurized gas can act on both sides of the plastic film 5, and thus gas bubbles are formed evenly in the plastic film 5. The discharge chamber 15 is sealed at the entry and exit of the plastic film 5 in a manner known per se.

[0018] After the machine direction orientation device 12 the plastic film 5 is supplied to a cross-direction orientation device 17. In the cross-direction orientation device 17 the plastic film 5 is stretched in the cross-direction, i.e. orientation is performed in the direction substantially perpendicular to the direction of the orientation performed in the machine direction device 12. Due to the overpressure of the gas in the bubbles and cross-direction stretching the bubbles can grow sideways and also to some extent in the vertical direction in the cross-direction orientation device 17. In that case the foaming degree of the film is for example about 70 to 90%. The foaming degree can be adjusted simply by adjusting the pressure of the gas to be fed into the discharge chamber 15. The cross-direction orientation device 17 comprises two orientation wheels 18, and an orientation band 19 is arranged against both of the wheels. The orientation band 19 is an endless band which is guided by means of band guide rolls 20. The orientation band 19 presses the edges of the plastic film 5 firmly and evenly between the orientation wheel 18 and the orientation band 19 substantially along the whole travel the cross-direction orientation device 17, in which case the film is not subjected to varying pressure stress or tensile strain, and thus the plastic film stretches sideways without tearing. In Figure 1 the plastic film 5, orientation wheel 18 and orientation band 19 are illustrated at a distance from one another for the sake of clarity, but in reality these parts are pressed firmly against one another. The orientation wheels 18 and the orientation bands 19 are arranged so that in the direction of the plastic film they are further away from one another at the end than at the beginning, as is illustrated in Figure 2, and thus the cross-direction orientation device 17 stretches and simultaneously orientates the plastic film 5 in the cross-direction. The deviation of the angle between the orientation wheels 18 and the orientation bands 19 from the machine direction can be adjusted according to the desired degree of cross-direction stretching. One or more band guide rolls 20 can be arranged to be rotated by the rotating means. Since the bands 19 are firmly pressed against the orientation wheels 18, the orientation wheels 18 do not necessarily need rotating means but may rotate freely. For the sake of clarity the enclosed figures do not illustrate rotating means or other actuators of the apparatus. A curved support plate 21, which has substantially the same shape as the circumference of the orientation wheels 18, is arranged between the orientation wheels 18 to support the plastic film 5.

[0019] The cross-direction orientation device 17 can be placed in a casing 26 of its own. If desired, the casing

26 can be provided with heaters known per se, such as radiation heaters, to heat the plastic film 5.

[0020] After the cross-direction orientation device 17 the plastic film 5 is led to a relaxation unit 22. In the relaxation unit 22 the plastic film 5 is relaxed, and thus the plastic film shrinks a bit in a manner known per se. Finally, the plastic film 5 is wound on a reel 23.

[0021] Figure 2 is a cross-sectional top view of the apparatus of the invention at the extruder 1. For the sake of clarity Figure 2 does not illustrate the plastic film 5 or the support structures of the apparatus onto which the rolls, reels and plates of the apparatus are attached, for instance.

[0022] Figure 3 is a cross-sectional view of a detail of the extruder 1 along line A-A of Figure 1. Here both the outer stator and the inner stator 4 are round in cross-section. Thus the plastic material 5a is also in an annular feeding channel.

[0023] Figure 4 is a cross-sectional view of a detail of the extruder 1 along line B-B of Figure 1. Here we see the wide tip of the inner stator 4 and the shape of the nozzle 6 which extrude the plastic 5a into the wide and flat gap, and thus a flat plastic film 5 is formed from the plastic 5a.

[0024] Figure 5 is a cross-sectional view of a detail of the cross-direction orientation device 17 along line C-C of Figure 1. It is seen in Figure 5 how the orientation wheel and the orientation band are pushed against each other and press the plastic film 5 between each other. The surface of the support plate 21 against the plastic film 5 may be heated e.g. by providing it with heating resistors, and thus the plastic film 5 slides along the sliding surface in question very easily. Furthermore, propellant, such as air, can be blown from the support plate 21 through the gaps 21a, in which case the propellant flowing through the gaps 21a provides a sliding bearing between the support plate 21 and the plastic film 5. The gas in question may be heated, if desired, and thus the sliding surface of the support plate 21 and the plastic film 5 are heated with the propellant flowing through the gaps 21a.

[0025] Figure 6 illustrates an extruder 1 used in the apparatus according to the invention. The nozzle 6 of the extruder 1 widens up to the end portion of the extruder, i.e. up to the point where the plastic film 5 exits from the extruder 1. In the nozzle 6 of the extruder 1 the plastic 5a is thus all the time subjected to cross-direction orientation in addition to longitudinal orientation, which makes it considerably easier to orientate the plastic film in the cross-direction at a later processing stage.

[0026] Figure 7a is a side view of the plastic film 5. Before extrusion calcium carbonate particles 24 have been mixed into the plastic 5a. Instead of calcium carbonate particles 24 some other material may also be mixed into the plastic 5a. The material should be such that it causes the joint surface of the plastic molecules and the material mixed into the plastic 5a to tear when the plastic film 5 is stretched so that cavitation bubbles are formed where the joint surfaces are torn. Thus some oily substance, such as silicone oil or paraffin oil, can be mixed into the plastic 5a.The particles mixed into the plastic 5a may cause spot-like asymmetry e.g. in the electric field in the plastic 5a, whereas the oily substance mixed into the plastic does not substantially worsen the electric properties of the plastic. It is also possible to mix a substance having a melting point lower than the orientation temperature of the plastic 5a, such as paraffin, into the plastic, in which case the substance melts when the plastic 5a is orientated. The plastic 5a may be made e.g. from polypropylene PP, polymethylpentene TPX or cyclic olefin copolymer COC. The heat resistance of polymethylpentene and cyclic olefin copolymer are better than that of polypropylene, for example. Electric charges also remain in polymethylpentene and cyclic olefin copolymer better than in polypropylene at high temperatures. Processing of polymethylpentene and cyclic olefin copolymer is very difficult but by the method and apparatus of the invention a very thin and foamed plastic film 5 can be made of them. In the situation illustrated in Figure 7a the plastic film 5 has not been stretched yet.

[0027] Figures 7b and 7c illustrate the plastic film 5 after it has been stretched in the machine direction orientation device 12, in which case the plastic film 5 has been simultaneously subjected to the pressure of the pressurized gas. In that case gas has diffused in the cavitation bubbles and caused overpressure in them, as a result of which bubbles 25 containing gas have formed. In the situation illustrated in Figures 7b and 7c the plastic film 5 has been subjected only to machine direction stretching, and consequently the bubbles 25 are long, flat and narrow.

[0028] Figure 7d illustrates a situation in which the plastic film 5 has also been stretched in the cross-direction by means of the cross-direction orientation device 17. The gas that was overpressurized in the bubbles 25 in the situation illustrated in Figures 7b and 7c has- released in the lateral direction in the cross-direction orientation device 17. Thus the bubbles 25 are now also wide. In addition, the bubbles 25 are flat, i.e. they are plate-shaped or disk-like. The bubbles 25 are relatively small, their diameter is at most about 100 micrometers and their height is typically less than one micrometer, at most about 10 micrometers. However, the method and apparatus provide very thin plastic films 5. The thickness of the plastic films 5 may be only 10 micrometers.

[0029] The plastic film 5 can be used for several purposes in a manner known per se. At least one surface of the plastic film 5 can be provided with an electrically conductive coating, for instance, in which case the solution can be used e.g. as a microphone or loudspeaker in several acoustic applications, including sound attenuation. The plastic film 5 may also be permanently electrically charged.

[0030] The drawings and the related description are only intended to illustrate the inventive concept. The de-

tails of the invention may vary within the scope of the claims. Thus the orientation directions of the plastic film 5 and the order of orientations in different directions may vary. According to the invention, the simplest way to make a plastic film is to orientate the plastic film in the machine direction first and thereafter in the direction transverse to the machine direction.

Claims

1. A method for producing a plastic film, the method comprising extruding a plastic film (5) and orientating it, **characterized in that** before extrusion material is mixed into the plastic (5a) of the plastic film (5), cavitation bubbles are formed in the plastic (5) film to be stretched due to the influence of the material, after extrusion the plastic film (5) is orientated by stretching, and simultaneously with orientation pressurized gas is arranged to act on the plastic film (5) so that the gas diffuses in the cavitation bubbles, and thus bubbles (25) containing gas are formed in the plastic film (5).

2. A method according to claim 1, **characterized in that** gas is arranged to act on the plastic film (5) at the first orientation stage and thereafter the plastic film (5) is subjected to a second orientation which is substantially perpendicular to the first orientation so that the bubbles (25) containing gas expand due to the influence of the second orientation and the gas.

3. A method according to claim 2, **characterized in that** at the first orientation stage the plastic film (5) is orientated in the machine direction and at the second orientation stage the plastic film (5) is orientated in the direction substantially transverse to the machine direction.

4. A method according to any one of the preceding claims, **characterized in that** the pressure of the gas acting on the plastic film (5) is over 3 bars.

5. A method according to any one of the preceding claims, **characterized in that** before extrusion an oily substance or a substance having a melting point lower than the orientation temperature of the plastic (5a) is mixed into the plastic (5a).

6. An apparatus for making a plastic film, the apparatus comprising an extruder (1) and at least one orientation device (12, 17) for orientating the extruded film (5), **characterized in that** the apparatus comprises gas supply means (15, 16) arranged in at least one orientation device (12, 17) for feeding pressurized gas into the plastic film (5) simultaneously with orientation by stretching so that the fed gas diffuses in the cavitation bubbles that are formed in the plastic film (5) during stretching, and thus bubbles (25) containing gas are formed in the plastic film.

7. An apparatus according to claim 6, **characterized in that** the gas supply means (15, 16) are arranged in the first orientation device (12) and that the apparatus comprises a second orientation device (17) after the first orientation device (12) in the direction of the plastic film (5), the second orientation device (17) being arranged to orientate the plastic film (5) in the direction substantially transverse to the orientation direction of the first orientation device (12) so that the bubbles (25) containing gas expand due to the influence of the second orientation device (17) and the gas.

8. An apparatus according to claim 7, **characterized in that** the first orientation device (12) is arranged to orientate the plastic film (5) in the machine direction and the second orientation device (17) is arranged to orientate the plastic film (5) in the direction substantially transverse to the machine direction.

9. An apparatus according to any one of claims 6 to 8, **characterized in that** the gas supply means (15, 16) comprise a discharge chamber (15), in which case at least one orientation device (12, 17) is arranged inside the discharge chamber (15) so that the pressure of the gas in the discharge chamber (15) acts on both sides of the plastic film (5) simultaneously with the orientation effect of the orientation device (12, 17).

10. An apparatus according to any one of claims 6 to 9, **characterized in that** the extruder (1) comprises a nozzle (6) which is arranged to widen up to the end portion of the extruder (1).

11. An apparatus according to any one of claims 6 to 9, **characterized in that** the apparatus comprises a cross-direction orientation device (17), which comprises two orientation wheels (18) and endless orientation bands (19) which are arranged against the wheels and move around band guide rolls (20), both edges of the plastic film (5) to be orientated being arranged between the orientation wheel (18) and the orientation band (19) and the orientation wheels (18) and the orientation bands (19) being arranged so that in the direction of the plastic film (5) they are further away from one another at the end than at the beginning, in which case the cross-direction orientation device (17) stretches the plastic film (5) in the cross-direction.

12. An apparatus according to claim 11, **characterized**

in that the apparatus comprises a curved support plate (21), which is arranged between the orientation wheels (18) to support the plastic film (5).

13. An apparatus according to claim 12, **characterized in that** the support plate (21) is provided with gaps (21a) and heated gas is arranged to flow through the gaps to heat the sliding surface of the support plate (21) and plastic film (5).

14. A plastic film, which comprises bubbles (25) with the maximum diameter of about 100 micrometers and the maximum height of about 10 micrometers, **characterized in that** material is mixed into the plastic (5a) of the plastic film (5), cavitation bubbles are formed in the stretched plastic film due to the influence of the material and the plastic film is subjected to stretching and to pressure of pressurized gas simultaneously with stretching so that the bubbles (25) contain said gas, the foaming degree of the plastic film (5) being over 70%.

15. A plastic film according to claim 14, **characterized in that** an oily substance or a substance having a melting point lower than the orientation temperature of the plastic (5a) is mixed into the plastic (5a) to provide the cavitation bubbles that are formed during stretching.

16. A plastic film according to claim 14 or 15, **characterized in that** the plastic film is made of polymethylpentene (TPX).

17. A plastic film according to claim 14 or 15, **characterized in that** the plastic film (5) is made of cyclic olefin copolymer (COC).

Patentansprüche

1. Verfahren zur Herstellung einer Kunststofffolie, wobei das Verfahren das Extrudieren sowie Recken einer Kunststofffolie (5) aufweist, **dadurch gekennzeichnet, dass** vor dem Einmischen eines Extrusionswerkstoffs in den Kunststoff (5a) der Kunststofffolie (5) Kavitationsblasen infolge des Einflusses des Materials in der zu streckenden Kunststofffolie (5) gebildet werden, nach dem Extrudieren die Kunststofffolie (5) durch Strecken gereckt wird und gleichzeitig beim Recken Druckgas so auf die Kunststofffolie (5) einwirkt, dass das Gas in die Kavitationsblasen diffundiert und so gashaltige Blasen (25) in der Kunststofffolie (5) entstehen.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** Gas in einer ersten Reckstufe auf die Kunststofffolie (5) einwirkt und die Kunststofffolie (5) anschließend einem zweiten Recken ausgesetzt wird, das im Wesentlichen senkrecht zu dem ersten Recken verläuft, so dass die gashaltigen Blasen (25) sich infolge des Einflusses des zweiten Reckens und des Gases ausdehnen.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** bei der ersten Reckstufe die Kunststofffolie (5) in Maschinenrichtung gereckt wird und bei der zweiten Reckstufe die Kunststofffolie (5) in die im Wesentlichen quer zur Maschinenrichtung verlaufenden Richtung gereckt wird.

4. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** der Druck des auf die Kunststofffolie (5) einwirkenden Gases bei über 3 Bar liegt.

5. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** vor dem Extrudieren eine ölige Substanz oder eine Substanz mit einem Schmelzpunkt unter der Recktemperatur des Kunststoffs (5a) in den Kunststoff (5a) eingemischt wird.

6. Vorrichtung zur Herstellung einer Kunststofffolie, wobei die Vorrichtung einen Extruder (1) und mindestens eine Reckeinrichtung (12, 17) zum Recken der extrudierten Folie (5) aufweist, **dadurch gekennzeichnet, dass** die Vorrichtung Gaszufuhreinrichtungen (15, 16) aufweist, die in mindestens einer Reckeinrichtung (12, 17) zum Einführen von Druckgas in die Kunststofffolie (5), gleichzeitig mit dem Recken durch Strecken, angeordnet sind, so dass das eingeführte Gas in die Kavitationsblasen diffundiert, die während des Streckens in der Kunststofffolie entstehen, und so gashaltige Blasen (25) in der Kunststoffolie entstehen.

7. Vorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** die Gaszufuhreinrichtungen (15, 16) in der ersten Reckeinrichtung (12) angeordnet sind und dass die Vorrichtung eine zweite Reckeinrichtung (17) nach der ersten Reckeinrichtung in der Richtung der Kunststofffolie (5) aufweist, wobei die zweite Reckeinrichtung (17) so angeordnet ist, dass sie die Kunststofffolie (5) in die im Wesentlichen quer zu der Reckrichtung der ersten Reckeinrichtung (12) verlaufende Richtung reckt, so dass die gashaltigen Blasen (25) sich infolge des Einflusses der zweiten Reckeinrichtung (17) und des Gases ausdehnen.

8. Vorrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass** die erste Reckeinrichtung (12) so angeordnet ist, dass sie die Kunststofffolie (5) in Maschinenrichtung reckt und die zweite Reckanordnung (17) so angeordnet ist, dass sie die Kunststofffolie (5) in eine im Wesentlichen quer zur Ma-

schinenrichtung verlaufende Richtung reckt.

9. Vorrichtung nach einem der Ansprüche 6 bis 8, **dadurch gekennzeichnet, dass** die Gaszufuhreinrichtungen (15, 16) eine Entladungskammer (15) aufweisen, wobei in diesem Fall mindestens eine Reckeinrichtung (12, 17) in der Entladungskammer (15) angeordnet ist, so dass der Druck des Gases in der Entladekammer (15) auf beide Seiten der Kunststofffolie (5) gleichzeitig mit der Reckwirkung der Reckeinrichtung (12, 17) einwirkt.

10. Vorrichtung nach einem der Ansprüche 6 bis 9, **dadurch gekennzeichnet, dass** der Extruder (1) eine Düse aufweist, die so angeordnet ist, dass sie zum Endabschnitt des Extruders (1) hin breiter wird.

11. Vorrichtung nach einem der Ansprüche 6 bis 9, **dadurch gekennzeichnet, dass** die Vorrichtung eine Querschnitts-Reckeinrichtung (17) aufweist, die zwei Reckscheiben (18) und endlose Reckbänder (19) aufweist, die gegen die Scheiben angeordnet sind und sich um Bandführwalzen (20) bewegen, wobei beide Ränder der zu reckenden Kunststofffolie (5) zwischen der Reckscheibe (18) und dem Reckband (19) angeordnet sind, und die Reckscheiben (18) und die Reckbänder (19) so angeordnet sind, dass sie in Richtung der Kunststofffolie (5) am Ende voneinander weiter entfernt sind als am Anfang, wobei in diesem Fall die Querschnitts-Reckeinrichtung (17) die Kunststofffolie (5) in Querschnittsrichtung streckt.

12. Vorrichtung nach Anspruch 11, **dadurch gekennzeichnet, dass** die Vorrichtung eine gebogene Stützplatte aufweist, die zwischen den Reckscheiben (18) angeordnet ist, um die Kunststofffolie (5) zu halten.

13. Vorrichtung nach Anspruch 12, **dadurch gekennzeichnet, dass** die Stützplatte (21) mit Spalten (21a) versehen ist, und erwärmtes Gas so durch die Spalte strömt, dass es die gleitende Oberfläche der Stützplatte (21) und der Kunststofffolie (5) erwärmt.

14. Kunststofffolie, die Blasen (25) mit einem maximalen Durchmesser von etwa 100 Mikrometern und einer maximalen Höhe von 10 Mikrometern aufweist, **dadurch gekennzeichnet, dass** ein Werkstoff in den Kunststoff (5a) der Kunststofffolie (5) eingemischt wird, Kavitationsblasen infolge des Einflusses des Werkstoffs in der gestreckten Kunststofffolie entstehen, und die Kunststofffolie gleichzeitig dem Strecken und dem Druck des Druckgases ausgesetzt wird, so dass die Blasen (25) das Gas enthalten, wobei der Schäumungsgrad der Kunststofffolie (5) über 70% liegt.

15. Kunststofffolie nach Anspruch 14, **dadurch gekennzeichnet, dass** eine ölige Substanz oder eine Substanz mit einem Schmelzpunkt unter der Recktemperatur des Kunststoffs (5a) in den Kunststoff (5a) eingemischt wird, um die hohlen Blasen zu schaffen, die während des Streckens gebildet werden.

16. Kunststofffolie nach Anspruch 14 oder 15, **dadurch gekennzeichnet, dass** die Kunststofffolie aus Polymethylpenten (TPX) besteht.

17. Kunststofffolie nach Anspruch 14 oder 15, **dadurch gekennzeichnet, dass** die Kunststofffolie (5) aus ringförmigem Olefin-Copolymer (COC) besteht.

Revendications

1. Procédé de fabrication d'un film plastique, le procédé comprenant l'extrusion d'un film plastique (5) et son orientation, **caractérisé en ce que**, avant l'extrusion, le matériau est mélangé dans le plastique (5a) du film plastique (5), des bulles de cavitation sont formées dans le film plastique (5) devant être étiré en raison de l'influence du matériau, après l'extrusion, le film plastique (5) est orienté par étirage, et simultanément à l'orientation, du gaz sous pression est agencé de manière à agir sur le film plastique (5) de telle sorte que le gaz se diffuse dans les bulles de cavitation, et de cette façon, les bulles (25) contenant du gaz sont formées dans le film plastique (5).

2. Procédé selon la revendication 1, **caractérisé en ce que** du gaz est agencé de manière à agir sur le film plastique (5) à une première étape d'orientation et par la suite, le film plastique (5) est soumis à une seconde orientation qui est sensiblement perpendiculaire à la première orientation de telle sorte que les bulles (25) contenant du gaz se dilatent en raison de l'influence de la seconde orientation et du gaz.

3. Procédé selon la revendication 2, **caractérisé en ce que**, à la première étape d'orientation, le film plastique (5) est orienté dans le sens machine et à la seconde étape d'orientation, le film plastique (5) est orienté dans le sens sensiblement transversal au sens machine.

4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la pression du gaz agissant sur le film plastique (5) est supérieure à 3 bars.

5. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que**, avant l'extru-

sion, une substance huileuse ou une substance ayant un point de fusion inférieur à la température d'orientation du plastique (5a) est mélangée dans le plastique (5a).

6. Appareil destiné à fabriquer un film plastique, l'appareil comprenant une extrudeuse (1) et au moins un dispositif d'orientation (12, 17) destiné à orienter le film extrudé (5), **caractérisé en ce que** l'appareil comprend des moyens d'alimentation en gaz (15, 16) agencés dans au moins un dispositif d'orientation (12, 17) destinés à introduire du gaz sous pression dans le film plastique (5) simultanément à l'orientation par étirage de telle sorte que le gaz introduit se diffuse dans les bulles de cavitation qui sont formées dans le film plastique (5) lors de l'étirage, et de cette façon, les bulles (25) contenant du gaz sont formées dans le film plastique.

7. Appareil selon la revendication 6, **caractérisé en ce que** les moyens d'alimentation en gaz (15, 16) sont agencés dans le premier dispositif d'orientation (12) et **en ce que** l'appareil comprend un second dispositif d'orientation (17) après le premier dispositif d'orientation (12) dans le sens du film plastique (5), le second dispositif d'orientation (17) étant agencé de manière à orienter le film plastique (5) dans le sens sensiblement transversal au sens d'orientation du premier dispositif d'orientation (12) de telle sorte que les bulles (25) contenant du gaz se dilatent en raison de l'influence du second dispositif d'orientation (17) et du gaz.

8. Appareil selon la revendication 7, **caractérisé en ce que** le premier dispositif d'orientation (12) est agencé de manière à orienter le film plastique (5) dans le sens machine et le second dispositif d'orientation (17) est agencé de manière à orienter le film plastique (5) dans le sens sensiblement transversal au sens machine.

9. Appareil selon l'une quelconque des revendications 6 à 8, **caractérisé en ce que** les moyens d'alimentation en gaz (15, 16) comprennent une chambre d'évacuation (15), auquel cas au moins un dispositif d'orientation (12, 17) est agencé à l'intérieur de la chambre d'évacuation (15) de telle sorte que la pression du gaz dans la chambre d'évacuation (15) agisse sur les deux côtés du film plastique (5) simultanément à l'effet d'orientation du dispositif d'orientation (12, 17).

10. Appareil selon l'une quelconque des revendications 6 à 9, **caractérisé en ce que** l'extrudeuse (1) comprend une tuyère (6) qui est agencée de manière à s'élargir jusqu'à la partie d'extrémité de l'extrudeuse (1).

11. Appareil selon l'une quelconque des revendications 6 à 9, **caractérisé en ce que** l'appareil comprend un dispositif d'orientation dans le sens transversal (17), qui comprend deux roues d'orientation (18) et des bandes d'orientation sans fin (19) qui sont agencées contre les roues et se déplacent autour de rouleaux de guidage de bande (20), les deux bords du film plastique (5) devant être orienté étant agencés entre la roue d'orientation (18) et la bande d'orientation (19), et les roues d'orientation (18) et les bandes d'orientation (19) étant agencées de telle sorte que, dans le sens du film plastique (5), elles sont davantage écartées les unes des autres au niveau de l'extrémité qu'au début, auquel cas le dispositif d'orientation dans le sens transversal (17) étire le film plastique (5) dans le sens transversal.

12. Appareil selon la revendication 11, **caractérisé en ce que** l'appareil comprend une plaque de support incurvée (21), qui est agencée entre les roues d'orientation (18) de manière à supporter le film plastique (5).

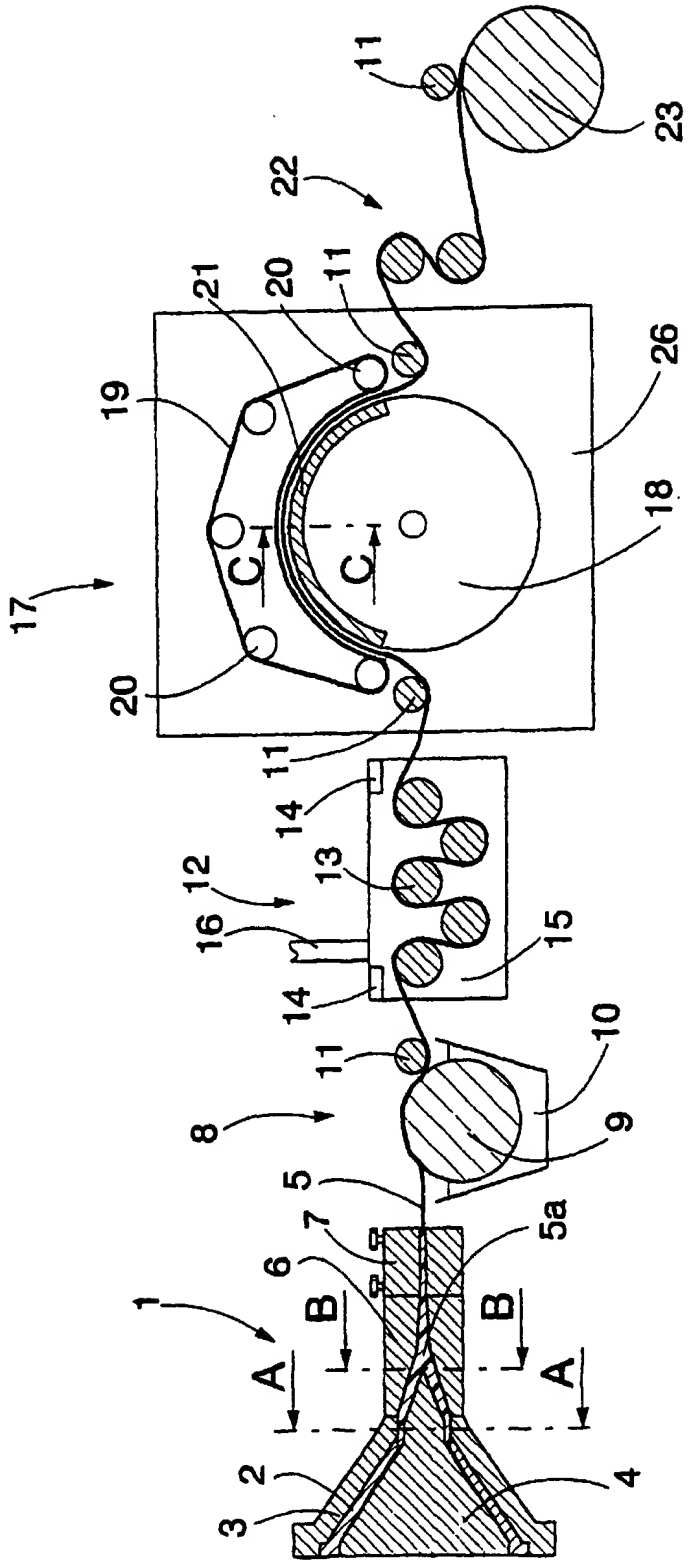
13. Appareil selon la revendication 12, **caractérisé en ce que** la plaque de support (21) est munie d'espaces (21a) et du gaz chauffé est agencé de manière à s'écouler à travers les espaces de manière à chauffer la surface coulissante de la plaque de support (21) et du film plastique (5).

14. Film plastique, qui comprend des bulles (25) avec un diamètre maximal d'environ 100 microns et une hauteur maximale d'environ 10 microns, **caractérisé en ce que** du matériau est mélangé dans le plastique (5a) du film plastique (5), des bulles de cavitation sont formées dans le film plastique étiré en raison de l'influence du matériau et le film plastique est soumis à l'étirage et à la pression du gaz sous pression simultanément à l'étirage de telle sorte que les bulles (25) contiennent ledit gaz, le degré de moussage du film plastique (5) étant supérieur à 70 %.

15. Film plastique selon la revendication 14, **caractérisé en ce qu'**une substance huileuse ou une substance ayant un point de fusion inférieur à la température d'orientation du plastique (5a) est mélangé dans le plastique (5a) de manière à fournir les bulles de cavitation qui sont formées lors de l'étirage.

16. Film plastique selon la revendication 14 ou 15, **caractérisé en ce que** le film plastique est fabriqué à partir de polyméthylpentène (TPX).

17. Film plastique selon la revendication 14 ou 15, **caractérisé en ce que** le film plastique (5) est fabriqué à partir de copolymère d'oléfine cyclique (COC).


11
23
22
21
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26
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C
C
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14
12
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16
15
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5a
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A
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3

FIG. 1

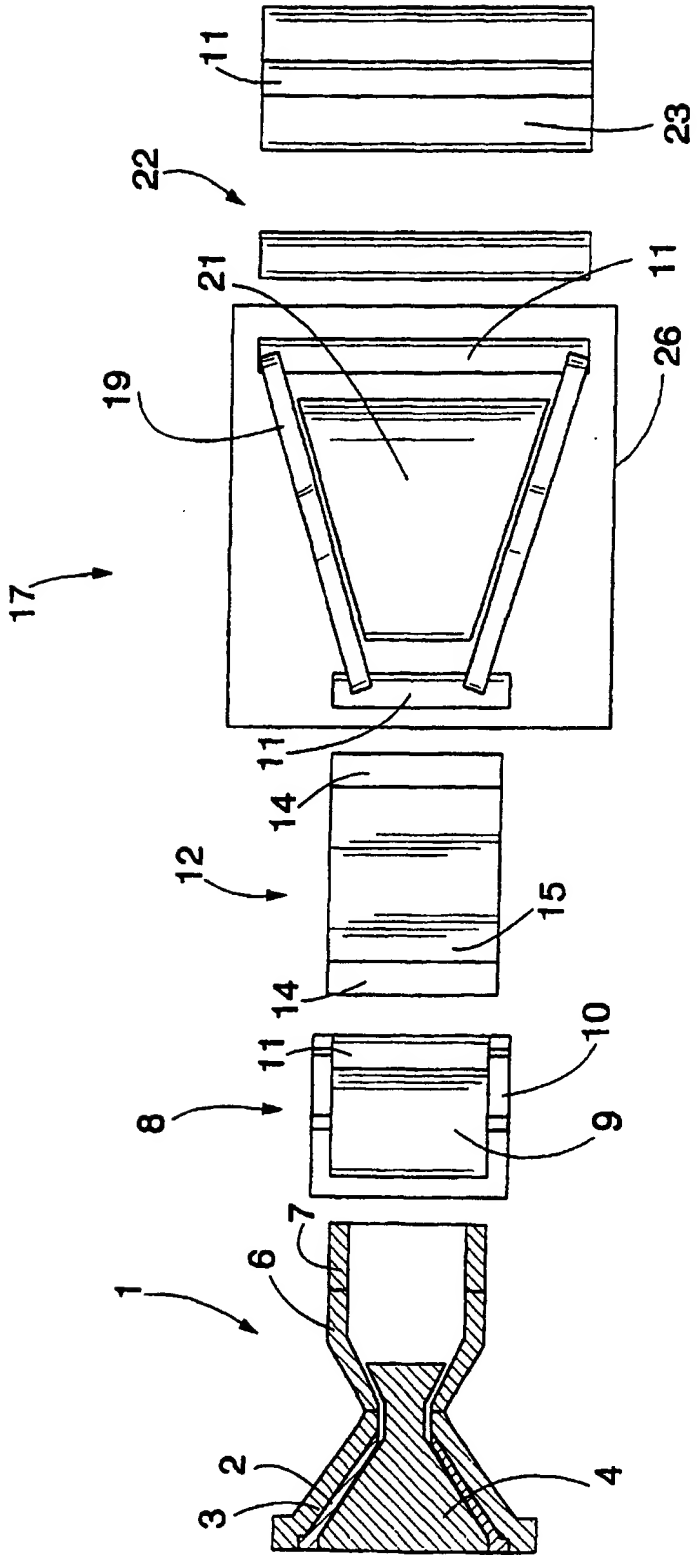

FIG. 2

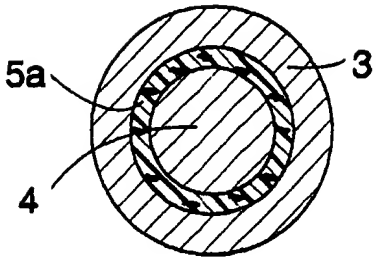

FIG. 3

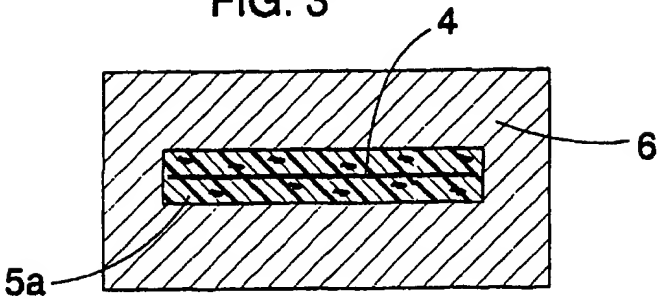

FIG. 4

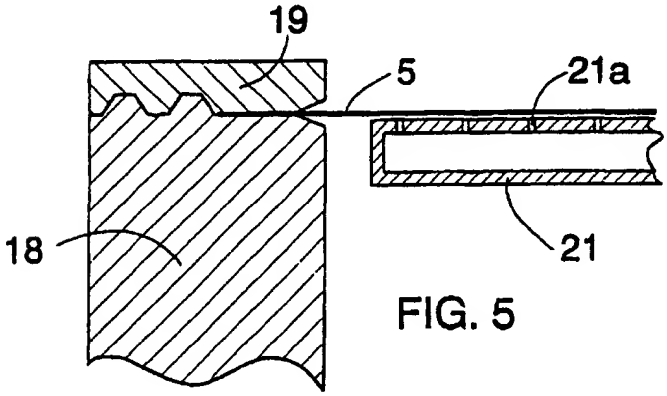

FIG. 5

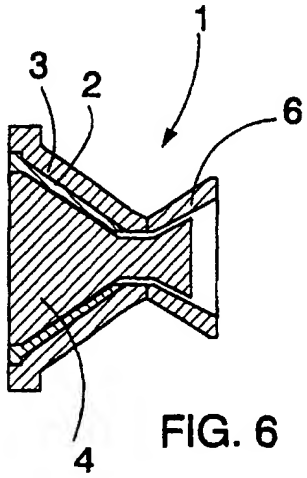

FIG. 6

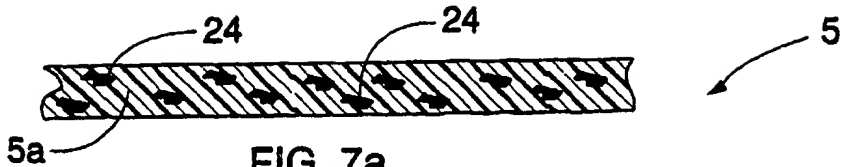

FIG. 7a

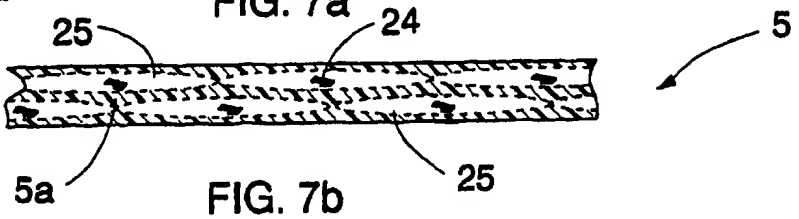

FIG. 7b

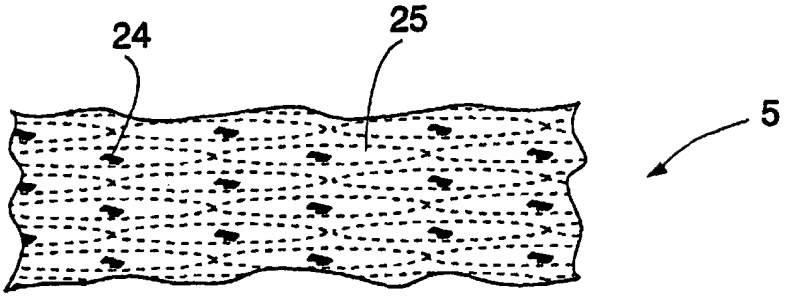

FIG. 7c

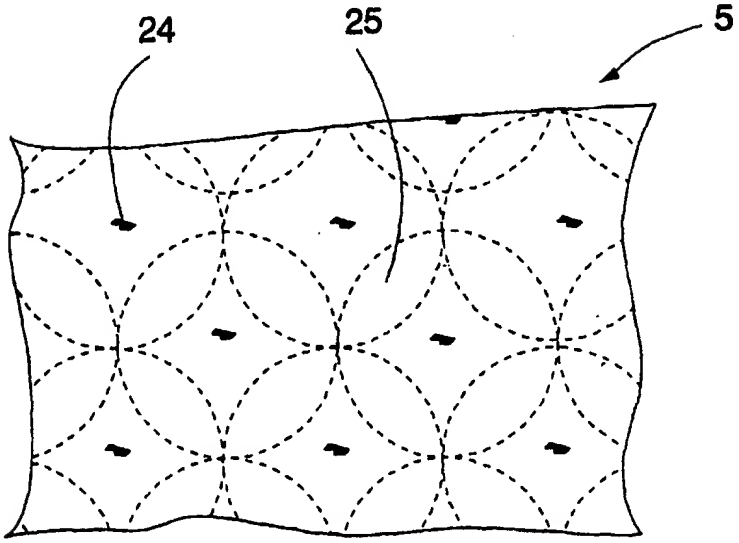

FIG. 7d